University of Texas Bulletin

No. 1852: September 15, 1918

NOTES ON THE GEOLOGY AND OIL POSSIBILITIES OF THE NORTHERN DIABLO PLATEAU IN TEXAS

By

J. W. BEEDE

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
DIVISION OF ECONOMIC GEOLOGY

J. A. UDDEN
Director of the Bureau and Head of the Division

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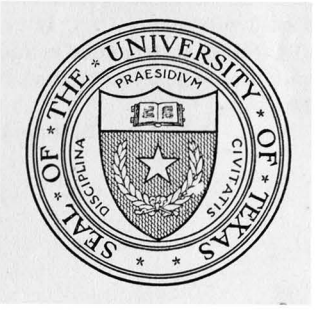

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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By J. W. Beede[1]

INTRODUCTION

A brief study was made recently of the northern portion of the Diablo Plateau to determine the likelihood of oil development on the University of Texas lands in Hudspeth County. In order to arrive at a proper understanding of the conditions to be encountered in drilling it was necessary to study the succession of the rocks of the Hueco Mountains, or escarpment, which form the plateau farther east. While this study was too hurried to permit the working out of all the complicated details of the geology of the Hueco escarpment, yet certain data were obtained which are of sufficient geologic and economic interest to warrant their publication. A word of appreciation is here due to the people of the Diablo Plateau and surrounding region, for the hospitality shown us and the unstinted assistance given us in pursuing our work; more especially to Mr. John Helms, Mr. John Molesworth, Mr. Wood, and Mr. Juan Escontrias. Their co-operation was of great value to us in making the hurried examination practicable.

Among the more important facts ascertained were the discovery of a considerable thickness of Mississippian beds, the unconformity at the top of the Magdalena beds, the unconformity within the Permian itself, and higher beds in the east edge of the Plateau.

The Diablo Plateau lies between the Hueco Mountains, or escarpment, on the west, and the Diablo Mountains, or escarpment, on the east. The northeastern limit is usually drawn from the Black Mountains to the Cornudas along a line of elevations formed by igneous intrusions.[2]

Note: Manuscript submitted May 17, 1920. Published Dec. 1920.

[1]Mr. C. E. Bowman assisted in the field work for this report.

[2]R. T. Hill, U. S. Geol. Surv., Geog. Atlas, No. 3, 1899.

Richardson, Geo. B., Univ. Tex. Min. Surv., Reconnaissance in Trans-Pecos Texas north of the Texas and Pacific Railway, 1904.

The present studies were confined to the northern part of this region. Roughly, the area here considered lies north of the latitude of the south side of Black Mountain, extending east from the Diablo Mountains to the edge of the Shakespeare escarpment, then turning northwest to the foot of the Hueco Mountains.

The first comprehensive treatment of the immediate region under consideration was the "Reconnaissance in Trans-Pecos Texas north of the Texas and Pacific Railway", by George B. Richardson[1]. In this report he gives a rather full bibliography up to the date of the publication, so that it only remains to note later work.

In Richardson's report the rocks of the Hueco formation, comprising the main part of the Diablo Plateau, were referred by Girty to the Pennsylvanian system. In his "Guadalupian Fauna", Girty places the Hueco formation at the base of the whole Guadalupian succession.[2] This is correct for all but a small part east and northeast of the Black Mountains. The peculiar collection of fossils referred to on page 26 of his book probably came from this locality.

In 1909, Lee and Girty published a paper on the "Manzano Group of the Rio Grande Valley"[3], in which the Manzano rocks were referred to the Pennsylvanian system, and suggested also that the Magdalena group below the Manzano group belonged to the same system.

Since the publication of his reconnaissance, Richardson has thrown much additional light on the Hueco region through his work in New Mexico in which he found that the Magdalena group and the Manzano group pass southward into the Hueco formation. The Magdalena was traced into the Franklin Mountains and the unconformity at its top was recognized there, but was not recognized in the Hueco escarpment. The Manzano was correlated with the Hueco and he states that "The sections which have been described (in West Texas and southeast New Mexico) can be approximately correlated and together they

[1]Richardson, ibid., Univ. of Tex. Min. Surv., pp. 119, 1904.
[2]Guadalupian Fauna, U. S. Geol. Surv., Prof. Paper 58, p. 11, 1908.
[3]W. T. Lee and Geo. H. Girty, U. S. Geol. Surv., Bull. 389, 1909.

comprise the local complete section of the Upper Carboniferous column. It appears that (a) the Hueco formation embraces both the Magdalena and Manzano groups of the Rio Grande Valley section in New Mexico....."[1] Since the Manzano Series was described prior to the Hueco, the latter term should be dropped.

Up to the present time the whole of the Hueco "formation" has been regarded as Pennsylvanian so far as printed references are concerned, except in two cases. One, a reference in an article entitled "A Comparison of Paleozoic sections in Southern New Mexico", by Darton,[2] contains the two following statements: "The Hueco limestone carries an abundant fauna regarded by Girty as of late Carboniferous age, on account of which at least the upper part of it has been tentatively correlated with the Kaibab limestone of northern Arizona"; "Pennsylvanian and Permian time is represented in the main by deposits of the Magdalena and Manzano groups and the Hueco and Gym limestones". The other reference is in a paper entitled "The Permo-Carboniferous ammonoids of the Glass Mountains of West Texas, and their stratigraphic significance", by Böse,[3] who places them in the basal Permian ("Permo-Carboniferous"), making it correspond to the Wichita and Clear Fork stages of Central Texas.

STRATIGRAPHY

A somewhat more detailed study of the Hueco escarpment reveals a number of additional facts of interest regarding the stratigraphic and faunal succession. As Richardson had already suggested, the Hueco formation contains both the Magdalena and Manzano groups of rocks, and in addition a considerable thickness of the Mississippian.

MISSISSIPPIAN

At the base of the Magdalena group is an unconformity that is not easily recognized. In the southern Huecos, these beds rest

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[1]Stratigraphy of the Upper Carboniferous in West Texas and southwestern New Mexico. Amer. Jour. Sci., 4th ser., XXIX, pp. 325-337, 1910. Quotation from p. 337.

[2]U. S. Geol. Surv., Prof. Paper 108, pp. 31-55, (ref. p. 55), 1917.

[3]Emil Böse, Bureau of Economic Geology and Technology, Univ. of Tex. Bull. 1762, chart facing p. 46, 1919.

directly on strata of Mississippian age. Usually there is a very sharp differentiation between the yellowish, thin-bedded Mississippian rocks and the more massive, light gray rocks of the Pennsylvanian beds. The Mississippian rocks rest unconformably on the Silurian limestone.

The local facies of the Mississippian rocks vary somewhat from place to place, though the main features are almost always present. North of Long Canyon nearly the whole series is made up of platy drab to dark-buff limestones which weather buff as a rule; with, locally, considerable chert in concretions, masses and layers, and some sandstone; all separated by thin layers of marl, weathering buff. Below these beds is a covered slope largely composed of clay shale, weathering buff. Much of the way the slopes of the formation are covered with rusty colored, thin parallelopipeds of siliceous limestone, giving them the appearance of an old tile yard. It should be noted here that there is a local occurrence of similar plates in a much higher horizon some ten miles southeast of this locality.

Fossils are present in most of the beds of this formation though very rare, except locally in the uppermost part of the section. Two and a half miles west of north of Helms' West Well, in a short canyon, the upper part of the formation is brought up by a fault. Here the limestones and calcareous sandstones are quite fossiliferous. The fauna includes two or more species of *Pentremites,* some three or four species of *Archimedes,* many bryozoa, Brachiopoda including species of *Diaphragmus, Spirifer, Spiriferina, Reticularia,* etc.; masses of crinoid fragments, cephalopods, and probably two species of trilobites. The whole formation is somewhere from 400 to 600 feet thick, and according to Dr. Weller is of Chester age, here designated the *Helms group.*

Upper Part of Section C[1]

About one mile south of Helms' Peak, beginning at the top of the Silurian limestone.

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[1]In order to preserve a record of the places where sections were measured and fossils were collected, Sections D, E, F, M and O were placed on the map.

		Ft.	In.
21.	Sandstone, dendritic, shaly	10	
20.	Sandstone and sandy-ferruginous limestone in three beds, sandstone in middle	6+	
19.	Concealed	68	
18.	Concealed with 2 feet sandy limestone at top	32	
17.	Limestone, a portion of which is ferruginous and sandy	6	
16.	Shale	5	
15.	Concealed, 8 feet, followed by limestones with shale partings, 19 feet	27	
14.	Limestone and shale beds, shale somewhat in excess of the limestone, the latter carrying small amounts of chert	25	
13.	Concealed	5	
12.	Limestone with a few shale partings carrying locally large masses and thin strata of chert	9	6
11.	Concealed	15	
10.	Shale and thin limestone beds some of which are 25 per cent chert, 6 beds in all	17	
9.	Concealed	8	
8.	Limestone with heavy beds and lenses of chert	11	
7.	Interval, mostly shale	18	
6.	Limestone, 2 beds, shale, 1 bed, weathers lighter than the rest, fossils from the lower one	3	
5.	Concealed	5	
4.	Limestone beds, 12; shale beds, 11	34	
3.	Shale, platy, same color as limestone	1	
2.	Limestone, very thin-bedded, almost laminated, breaks down into thin quadrangular plates, brownish-buff within, rusty to buff outside	2	
1.	Concealed, 65 feet, plus allowance for dip	100	

All the limestones below number 19 are like those described in number 12. In fact, nearly all the limestones of the whole section are yellowish-brown.

It is not certain that the whole section is visible at the location of Section C. The base may or may not be faulted out. Farther southeast there is a very considerable part of the section which, it seems, is not represented here. There is a considerable thickness of light drab, thin limestones weathering nearly white, beneath which there are about 100 feet of dark-olive shales. The limestone may be a very long lens or may be faulted out of the northern part of the exposure. Time did not permit the determination of this point, but it seems probable that it is faulted down. The

following section in the valley west of Rancheria Mountain gives a very good idea of the condition of the lower part of the section as exposed here.

Section T

Feet

2. Limestone, thin, drab, weathers nearly white to gray, minutely channeled surface, some chert, with thin, minutely arenaceous cherty plates between the beds. Indurated marls also occur between the limestones.....90 to 80
1. Shale, somewhat papery, ripe-olive shade, about....115 to 100

PENNSYLVANIAN

Resting unconformably on top of the Chester beds is a section of Pennsylvanian sediments, the Magdalena Group. It is possible to divide these beds into three lithologic units, though limestone is the chief component of each of them. The lower one is practically a massive limestone section, light gray in color, some parts of it quite cherty, while some horizons are quite fossiliferous. The chief fossils are *Chaetetes*, which occurs in reefs, one prominent stratum three to eight feet thick composed of it being traceable three or four miles; *Lophophyllum; Michelinia*, and other corals; brachiopods, etc. The second part contains marly fossiliferous shales of moderate thickness between the limestone beds. *Chaetetes* is more rare, while *Chonetes mesolobus, Prismopora triserrata, Chonetes laevis* Keyes (not *C. geinitzi* of the higher horizons of the Mississippi Valley) are present, and in fact, a considerable part of the fauna found in the Des Moines group of Kansas. The upper, or third part, consists more largely of massive, frequently quite cherty limestones in which the shales play a minor role. The limestones are light buff in shade and well filled with fossils. The Magdalena beds have an aggregate thickness of about 1100 feet.

Section G

Up the northeast side of the notch in the west side of the mountain of which 5392-foot Helms Peak forms the top, seven and a half miles east of south of the Hueco Tanks. Section extends to the top of the westernmost of the two peaks west of Helms Peak, which is two and a half miles north of Helms' West Well.

		Ft.	In.
67.	Limestone, disturbed and partly sunken into shale below. (Small fault?)	10	
66.	Concealed	15+	
65.	Limestone, shaly, cherty, fossiliferous	2±	
64.	Concealed	6	
63.	Limestone, flesh-gray, *Monilopora prosseri*, branchiopods, etc.	1	6
62.	Interval, probably shale slope, fossils,	3	
61.	Limestone, flesh-gray, coarse, cherty, fossiliferous	2±	
60.	Shale, fossiliferous	6±	
59.	Limestone, cherty, continues to top of saddle. Near the fault is a 2 foot limestone which weathers rusty-brown, very conspicuous, pieces of it appear some distance from the fault	17	
58.	Concealed	5+	
	On the talus slope between the reef and the top of the hill are beautiful specimens of *Monilopora prosseri* and *Chaetetes*.		
57.	Limestone, massive, fossiliferous	7	
56.	Talus slope	18	
55.	Limestone, massive, cherty, *Fusulina*	3	
54.	Shales with thin limestone in middle, tiny *Fusulinas* first seen	10	
53.	Limestone filled with very dark chert	10±	
52.	Shales, limestones and chert slumped down	7	
51.	Limestone, very cherty	8	
50.	Concealed, with coarse limestone at top	3	
49.	Limestone, massive, considerable *Chaetetes*	3	6
48.	Limestone 2 feet, concealed 5 feet	7	
47.	*Chaetetes* reef, 3 feet thick on point, 6 feet thick in places, usually about 3 feet	3	
46.	Shale, appears to pinch out in 100 yards	8	
45.	Limestone, dense, alternating with chert beds a foot thick	18	
44.	Limestone, fossiliferous, shaly, *Chaetetes*, gastropods	20	
43.	Shale 3 feet, limestone 7 feet	10	
42.	Limestone, fine-grained, crystalline, reef bed with chert 3 feet below top	9	
41.	Limestone and shale, very fossiliferous	5	
40.	Shales with white chert about 1 foot thick in them, very fossiliferous	6	
39.	Limestone, fine-grained, massive in 3 beds	19	
38.	Limestone breccia with *Chaetetes*, large gastropods, etc., sponges; chert bed at base	1½ feet to	3
37.	Limestone, fine-grained, buff-gray, foraminiferal	8	

		Ft.	In.
36.	Interval, marls at top	3	
35.	Limestone, thin-bedded	6	
34.	Limestone, very cherty	12	
33.	Limestone, semi-lithographic, light gray, thin chert band near top	8	
32.	Limestone, coarse-grained, finer near top, flesh gray	12	
31.	Concealed, contains a blue cherty limestone	3	
30.	Limestone, semi-lithographic, blue-gray, heavy chert bed in middle and cherty on top	12	
29.	Limestone, gray, massive, crystalline, 3 layers	16	
28.	Limestone, light gray, semi-lithographic	7	
27.	Limestone, massive, light buff-brown, some fine chert on top, fossils	11	
26.	Limestone, dark colored, very cherty, except 5 feet at base which is less cherty and foraminiferal	27	
25.	Limestone, massive, very cherty, chert usually in thick bands, but frequently bands are united through the intervening limestone beds; large foraminifera	20	
24.	Limestone reef, massive, few fossils, no chert, limestone in 3 or 4 ledges	95	
23.	Limestone reef, finely sugary crystalline	30	
22.	Concealed, probably faulting	5	
21.	Limestone, crystalline, dark buff-gray, cherty. Some corals and other fossils. Heavy chert bed at the top	4	
20.	Limestone, fine-grained, crystalline, little chert	7	
19.	Limestone, thin-bedded, dense, blue, some chert	4	
18.	Concealed	4	
17.	Limestone, coarse-grained, dark buff, reef-like	12	
16.	Limestones, thin, with marl partings, little chert and fossils	5	
15.	Limestone, reef-like, rather coarse, chert band 5 feet above base and 3 foot chert zone at 15 feet, *Camphophyllum*	22	
14.	Concealed	6	
13.	Limestone, light to dark buff, weathers a little darker than the other beds. Sparingly cherty; *Camphophyllum*	15	
12.	Limestone, cherty, *Camphophyllum* bed at top		5
11.	Concealed	4	
10.	Limestone, reddish gray, weathers mottled, many *Camphophyllum*	14	
9.	Shale 2 feet, with some thin limestone sheets, somewhat thicker limestones above, large *Camphophyllum, Michelinia, Lithostrotion* (?)	6	
8.	Limestone, weathers granular, moderately coarse-		

		Ft.	In.
	grained, light buff, fossils, ostracods	9	
7.	Limestone reef (?) bed, massive, semi-lithographic, brownish-buff, chert at base. Spots resembling *Fusulina* are not *Fusulina. Chaetetes*	6	
6.	Limestone, hard, blue-gray	2	
5.	Limestone bed, lighter colored and more crystalline than number 4	8	
4.	Limestone, massive, semi-lithographic, buff-brown, corals, brachiopods. Weathers darker than lower beds	9	
3.	Limestone, poorly exposed, thin-bedded below	4	
2.	Limestone, with 1 foot concealed slope below, rather fine-grained, buffish-gray to brown inside	5	
1.	Limestone, two massive beds, fine to coarse-grained, corals, crinoid stems, and brachiopods	4	

Beneath number 1 of this section is the Mississippian section, a fair part of the upper third of which is exposed here, and is quite fossiliferous.

Section H

Up south side of Helms Peak, 2½ miles north of Helms' West Well. Section, beginning with number 21 of Section H, rests on top of number 59 of Section G.

		Feet	In.
29.	Limestone, chert fragments, large sea-urchin spines, and plates, brachiopods, etc., quite fossiliferous	5	
28.	Concealed	40±	
27.	Limestone, similar to number 25. No *Lithostrotion* noted	1	6
26.	Limestone, weathers whitish, and shales	5	
25.	Limestone, coarse-grained, foraminiferal, crinoidal; *Lithostrotion* colonies, 5 feet to	3	
24.	Concealed	20	
23.	Limestone, siliceous, dark brownish-gray, fossils	3	
22.	Concealed	20	
21.	Interval, with light colored chert at the top, beds of this interval quite fossiliferous; *Prismopora*, etc.	25	
20.	Limestone, somewhat massive, rather cherty below and quite cherty at top, sparingly fossiliferous, "Caudigalli" at top	17	

Number 21 rests on number 59 of Section G. The interval between the *Chaetetes* reef and the limestone at the top of

Section G seems to be a little shorter in Section H. This is probably due to the difficulty in getting a good section at the latter place on account of disturbed conditions. There seems to be a fault crossing the section near the top of Section H.

Section K

Mountain south of the Blabber Tanks, five miles a little east of south of the Hueco Tanks. This section is supposed to begin at the top of Section H, in the mountains farther south

		Feet	In.
37.	Clay, red, apparently part of unconformity, old weathered beds, 0-100 feet thick, here 45-50 ft. thick contains fossils washed down slope from beds above.	50	
36.	Limestone, lithographic, with calcite seams and crystals, very light buff	27	
35.	Concealed	12	
34.	Limestone, light-gray, somewhat craggy	12	
33.	Interval, 15 inches of flint just above base, 6 inches of limestone near the top	6	
32.	Limestone, semi-lithographic, flesh-colored, fossils	5	6
31.	Concealed	6	
30.	Limestone, broken-cherty, chert light colored, limestone nearly white, large *Composita*, etc.	13	
29.	Concealed	25	
28.	Limestone, light buff-gray, some chert	11	
27.	Interval, apparently cherty limestones and shale	6	
26.	Limestone, gray, coarse, fragmental	1	6
25.	Interval. Mostly limestone and marl	6	
24.	Limestone, cherty, fossiliferous, dark buff-gray	6+	
23.	Marls, with two thin cherty limestones	10	
22.	Limestone, semi-lithographic, cherty, dark gray	4	
21.	Concealed	8	
20.	Limestone, fine-grained, cherty, light buff	6+	
19.	Limestones, quite cherty	9	6
18.	Concealed	6+	
17.	Limestone, thin-bedded, cherty, very fossiliferous, *Monilopora*, etc.	10+	
16.	Limestone, very fossiliferous	13	
15.	Limestone, craggy, cherty, dark gray, *Camphophyllum*	6	
14.	Concealed	4	
13.	Limestone, massive bed, minutely crystalline, craggy, light gray, sparingly cherty, large *Camphophyllum*	23	
12.	Limestone, more cherty than 11	3	

		Feet	In.
11.	Limestone, cherty, dark buff, fossiliferous	2	6
10.	Concealed	10±	
9.	Limestone, coarse-grained, cherty near top, some chert throughout, dark flesh-gray, fossils	25	
8.	Concealed	5	
7.	Limestone, fine-grained, gray, cherty	2	
6.	Concealed	5	
5.	Limestone, hard, brittle, minutely cherty	3—	
4.	Concealed	10	
3.	Limestone, crinkly, semi-lithographic, light buff-gray	2	6
2.	Concealed	10—	
1.	Limestone, fine-grained, fragmental, light-gray to fleshy-gray, few fossils	9	

PERMIAN (PERHAPS CONTAINING SOME PENNSYLVANIAN)

The upper part of number 37 of the previous section rests unconformably upon the remainder of the section. It is the same unconformity mentioned in Section B, following. This unconformity separates the Magdalena group from the Manzano group.

This unconformity is marked by a foreign conglomerate composed largely of well rounded to angular chert, some of which is quite green in color, and some quartz and quartzite, though the last two are rare. They are usually cemented with calcium carbonate and locally grade into conglomeratic or sandy limestones. The conglomeratic beds contain shale and are sometimes accompanied by as much as fifty to nearly a hundred feet of red, residual clay. Sometimes the conglomerate and associated beds are nearly wanting.

The angular unconformity of the beds varies in different places and in different directions. South of the Hueco Tanks it varies locally from 14 degrees to 21 degrees in a northeasterly direction, but is nearly parallel in a direction normal to it.

Over the unconformity at the top of the Magdalena beds comes a thick section of limestones of darker hue, some quite cherty and some of them free from chert. Many of them are siliceous, and some have well silicified fossils. There are some thin shale beds present, but many of the concealed intervals are composed of limestone that happens to weather faster than that next to it

at that particular exposure. In some places the beds are massive and nearly homogeneous, forming practically a single bed a hundred feet or more thick, which, on escarpments, tends to break up vertically rather than into beds, though bedding planes are visible. In fact, they seem to be great reefs, though the reef structure is less apparent than is frequently the case.

The lithologic features of these limestones are so similar that it is often impossible to form an accurate idea of the true stratigraphic position of the surface rocks at any particular part of the plateau, or to refer them to a position closer than five to eight hundred feet in the general section unless diagnostic fossils can be found. On account of surface changes which have taken place—solution and recrystallization, etc.—it is frequently difficult to obtain these fossils in recognizable form unless rather deep cuts are found. Their position can be determined by carefully working out all details of the stratigraphy of each ridge, but the time at our disposal was far too limited to permit this to be done.

The section at Juan Peak[1] and the section of Hueco Canyon give a good idea of the Permian rocks of the western half of the plateau.

Section B

Section of Juan Peak, the high mountain on edge of Hueco Escarpment, north 20° east of Hueco Tanks ranch house.

		Feet	In.
81.	Limestone, coarse to fine-grained, weathers to buff shade, chert	15	
80.	Marls filled with fossils	6	
79.	Limestone, less cherty than number 78, very fossiliferous in upper part, fossils somewhat different from those below. Giant *Meekellas*	6	6
77.	Limestone, hard, even-bedded, coarse-grained, cherty, fossiliferous	35	

[1]Juan Peak is so named for Juan Escontrias, who showed us almost unlimited favors during our stay at the Hueco Tanks. It is the high point N. 20° E. of the house. It is practically between the two largest masses of intrusives along the escarpment north of the Hueco Canyon road.

		Feet	In.
76.	Limestone, hard, crystalline, gray, calcite sheets in joints, weathers to buff-gray shade	10	
75.	Limestone, hard, foraminiferal, gray, sparingly cherty	5	6
74.	Concealed	5	
73.	Limestone, much more fossiliferous than number 72, cherty, gray, calcite sheets in joints	9	
72.	Limestone, coarse, foraminiferal	8	
71.	Concealed	6	
70.	Limestone, coarse, rough, siliceous, calcite veins in the joints. Two beds, composed of fragments of fossils, crystalline, yellow and red spots	3	6
69.	Shales, fossiliferous	2	
68.	Limestone, siliceous, resembling that below	5	
67.	Marls and marly limestones, very fossiliferous in lower part	20	
66.	Limestone, like two limestone beds below	6	6
65.	Shale, some fossils	4	
64.	Limestone like number 59, thicker-bedded, siliceous, microfauna	5	
63.	Shale, quite fossiliferous	10	
62.	Limestone, hard, brownish, granular, thin-bedded, sandpaper surface, upper bed fossiliferous	7	
61	Limestone, massive, coarse, siliceous, rusty brown	5	
60	Concealed	5	
59.	Limestone, several beds, coarse, buff, silicified fossils	8	
58.	Limestone weathering into large blocks with rounded edges, which look like sandstone; buff color. Top fossiliferous; *Schwagerina*	10	
57.	Limestone, 4 beds, hard, massive, blue-gray, weathers to dark dirty-gray or drab	3	6
56.	Interval. Shales above, quite fossiliferous, *Schwagerina*	40	
55.	Sill with flow structure, almost pumaceous	12	
54.	Concealed, probably a sill (25 feet of same showing farther south) from baked shale upward	25	
53.	Concealed, with 8 inches to a foot of yellowish baked clay at the top	10	
52.	Limestone, very fine-grained, hard, blue-gray, sandpaper-like surface due to minute pits	4	6
51.	Limestone, dense, fine-grained, hard, dark blue, 3 beds	1—	8
50.	Limestone, massive bed, texture like number 49	3	6
49.	Limestone, more closely faceted, frequently appearing without bedding planes. Texture like the above massive beds	10	6
48.	Limestone, hard, rather massive beds, weathers to buff-		

		Feet	In.
	ish hue speckled with elongated drab spots which are fragments of fossils	9	
47.	Interval, contains 6 inch ledge of yellowish weathered sill	9	
46.	Limestone 4 feet, with about 2 feet of clay (?) limestone, very hard, brittle, darker on surface than within	6	
45.	Limestone, semi-lithographic, amber calcite crystals, weathers drab, browner within	2	
44.	Limestone, few if any bedding planes, much like those below, weathers to dark dirty-buff shade	15	
43.	Limestone, much like number 42, 20 feet to	23	
42.	Limestone, more massive, less sharply jointed than number 41, weathers a little more yellowish	5	
41.	Limestone, fine-grained, brittle, bituminous, dark blue-gray; lower half quite fossiliferous, *Archaeocidaris*, *Productus*, trilobite, sponges. Sharply jointed into small blocks	22	
40.	Concealed. Probably shale	10	
39.	Limestone, thin-bedded, dark gray, many *Pugnax*, sea urchin spines and small plates. Long *Fusulina* rare	3	±
38	Concealed, probably marls	30	±
37.	Limestone, very hard, buff-gray bed, vermicular foraminifera, otherwise like number 36. Top of second big ledge	7	
36.	Limestone, coarse-grained, rough, gray	2	
35.	Limestone conglomerate composed of rounded pieces (concretions?) of limestone from one foot in diameter to the size of marbles and averaging a little larger than eggs. Some marly matrix	4	
34.	Limestone, foraminiferal, fairly thin-bedded, hard, brittle, gray, has tendency to weather into blocks with rounded edges	46	
33.	Concealed, 15 feet to	10	
32.	Limestone, four main and many minor beds, resembles number 31 but is more massive and styolitic, more fossiliferous with micro-fauna in lower part, buffish-gray outside and in. First heavy ledge	16	
31.	Limestone, gray, nodular. finely mottled, shale partings. In the ravine is a nearly black limestone with small *Fusulinas*, perhaps not in place	10	
30.	Limestone, hard, gray-buff, mottled within, semi-lithographic with calcite streaks; weathers rough	6	
29.	Concealed. 10 feet to	15	

		Ft.	In.
28.	Limestone, somewhat laminated, thin, separated by soft shales containing limestone nodules	5	
27.	Concealed, about	23	
26.	Shale, calcareous, bluish, streaked with gray, about 15 inches above number 25, weathers slaty, now hard and brittle. Softer shales in the interval	2	3
25.	Limestone, dense, fine-grained, black, brittle, conchoidal fracture. Weathers very smooth, slaty shade on outside	2	
24.	Concealed	4	
23.	Limestone, massive, hard, two layers with shaly limestone parting, upper part quite cherty, lower bed slightly so, light to stone-gray throughout, composed of ground fossils. Foraminifera in the lower bed	3	6
22.	Shale and nodular limestone	3	6
21.	Limestone, massive, rather coarse-grained, conchoidal fracture, blue, weathers rusty mottled. Quite fossiliferous	1	6
20.	Shale, calcareous, with limestone nodules; blue, weathers to buff-gray. *Productus*, *Chonetes*, Ostracoda, *Pugnax*, trilobite, etc	3	6
19.	Concealed	5	
18.	Limestone, nodular, thin-bedded, semi-lithographic, fossiliferous, buffish-gray to drab outside and inside. *Composita*, *Productus*, etc	2	6
17.	Concealed	3	6
16.	Firmer and denser bed of same material as number 15.	5	
15.[1]	Pumice-like sill	6	
14.	Interval. The highest fragments of the conglomerate were seen twenty feet above the limestone mentioned in number 13, leaving total thickness of the conglomerate 45 feet at this place	40	
13.	Interval. Contains six inches to a foot of limestone, weathering gray	20	
12.	Conglomerate, calcareous matrix; red, brown. green and black chert, etc., rather fine below, coarse above, some sandstone pieces six inches in diameter. *Fusulina*	5	
11.	Concealed	15	
10.	Limestone, pebbly, semi-lithographic texture	2	+
9.	Concealed	5	
8.	Conglomerate, broken down	5	

[1]Number 15 is number 1 of the original section. Fossils collected are numbered according to the first section, in which number 15 is called number 1, etc.

		Feet	In.
7.	Concealed	7	
6.	Limestone, metamorphosed, blue-black, flinty fracture, fragments of fossils	3	
5.	Concealed	13+	
4.	Conglomerate, limestone, two or three beds	1	3
3.	Concealed	35	
2.	Marls, platy, with limestone plates, hard, weather gray	10	
1.	Limestone, shaly, impure, blue, weathers gray	4	

Farther north along the escarpment higher beds of very considerable thickness come in. However, the section in the Hueco Canyon probably covers these beds fairly well.

Section J

Section up Hueco Canyon to Lincoln Tank. Section begins near the base of the first heavy limestone above the unconformity and conglomerate, and duplicates all of Section B above that horizon. Measured over hills on south side of Hueco Canyon road.

		Feet	In.
53.	Limestone, thin-bedded, very fossiliferous, poorly exposed, *Solenomya*, *Omphalotrochus*, *Pugnax*, etc.	40+	
52.	Limestones, perhaps more siliceous than number 51, forming sharper and higher scarps, and appearing harder on the surface, about as cherty as number 51; top of more massive beds. *Pugnax*. Most of the small fossils of number 51 have dropped out	180	
51.	Limestone, rather fine-grained, quite siliceous, somewhat cherty throughout, thin-bedded, fossiliferous, many gastropods from minute *Loxonemas* to very large *Omphalotrochus*, *Productus*, *Pugnax*, etc.	330	
50.	Limestone, thin-bedded (on top of hill), fossils	5	
49.	Limestones, thin, and marls, fossiliferous, very poorly exposed	58	
48.	Limestone, very fossiliferous	10	
47.	Concealed, some shales	15	
46.	Shales and thin fossiliferous limestones	35	
45.	Interval, apparently shale	10	
44.	Limestone, massive, very fossiliferous	25	
43.	Limestones on covered slope	17	
42.	Limestone beds, massive, somewhat cherty, rather thick	18	

		Feet	In.
41.	Massive limestone, very fossiliferous	13	
40.	Concealed	17	
39.	Limestone, very fossiliferous, lighter than 38	7	
38.	Limestone like those below, silicified fossils	7	
37.	Interval, apparently contains limestones like number 36	80	
36.	Limestone ledge, little chert, fossiliferous, *Omphalotrochus*, large "Bellerophons"	5	
35.	Concealed, partially, consists largely of thin-bedded limestones, no chert noticed	80	
34.	Limestone, buff-brown, marly at the base	6	
33.	Concealed, apparently composed of thin limestones and marls		
32.	Interval, contains limestones weathering into chips on the surface	40	
31.	Limestones, fossiliferous, blue-gray, separated by indurated marls	30	
30.	Concealed	5	
29.	Interval, mostly limestone less resistant than that below, fossils, large gastropods	50	
28.	Limestone, rather thin-bedded, brittle, bituminous, breaks into small blocks	100	
27.	Limestone, light-buff, massive	18	
26.	Concealed	15	
25	Limestone, dense, dark blue, bituminous	3	
24.	Concealed (This bed, apparently shales, is almost pinched out along the road up the canyon on account of folding.)	80	
23.	Limestone, blue-gray, with 4 feet of shale	12	
22.	Limestone, massive, reef-like	25	
21.	Limestone, light colored, bituminous, somewhat foraminiferal	13	
20.	Limestone, rather massive	6	
19.	Limestone, gray, bituminous, weathers chippy	6	
18.	Limestone, like number 17, columnar joints	10	
17.	Limestone, massive, slightly cherty, reef (?)	25+	
16.	Limestone, massive, dark, very cherty	20	
15.	Limestone, coarse, light buff below, finer and darker above, with scattered chert nodules, appears as reef bed little farther west	14	
14.	Interval. Contains a foot of limestone and some chert nodules	6	
13.	Limestone, massive	5	
12.	Concealed	8	
11.	Limestone, rather fine-grained and light colored	15	

		Feet	In.
10.	Concealed	7	
9.	Limestone, brownish	7	
8.	Concealed	5	
7.	Limestone, buff-brown	7	—
6.	Concealed	5	
5.	Limestone, massive, dark buff	6	
4.	Concealed, contains buff-brown limestone, gastropods.	5	
3.	Marls with nodular limestone, 8 feet, followed by 26 feet of massive limestone	34	
2	Concealed, 20 feet to	12	
1.	Limestone, hard, fine-grained, massive, buff-brown, 4 or 5 beds	30	

Up a canyon practically all the beds from the top of 5 or 7 to the top of number 23 show as a continuous reef-like bed.

In going from number 50 to number 51 a canyon is crossed which owes its origin to a fault. On the side of the valley there is much brecciated limestone and the drag is very strong so that the beds approach a vertical position. The block to the east has been dropped. How much has been elided from the section here, it is impossible to say.

The valley in which Cedar Tank and Number 1 Tank are located is also a fault valley which terminates the top of Section J.

In the southeastern Huecos, from Shakespeare Tank westward, there is still another unconformity represented by a conglomerate of rounded limestones, thoroughly rounded quartz and quartzite pebbles, etc. The basal bed is usually cemented with the brown to black oxides of iron, while the rest of the beds have a calcareous cement, the uppermost grading into a sandy limestone, the sand being largely composed of chert grains.

This conglomerate has a maximum thickness of about a hundred feet. It overlaps the underlying Permian strata in a northeast direction, the beds of the two formations having an angle to each other of 18 degrees. It is not improbable that this conglomerate would overlie the whole Manzano group in the northern Huecos had it not been removed by erosion. It apparently does overlie it—unless a large part of the underlying beds has been removed by erosion—on the Salt Basin road just west of Brackett Draw. There are no Permian deposits above it in the south-

western part of the plateau and a question might legitimately be raised regarding its age. However, it appears to be a Paleozoic deposit, very different from anything seen in higher horizons in this vicinity. It is folded to a greater degree than the overlying Cretaceous sediments, and apparently passes beneath higher Permian deposits in the region of Brackett Draw, on the west side of Salt Flat. Two detailed sections, one on either side of the road, west of Shakespeare Tank, give a fair idea of its structure and appearance.

Section N

Two and a half miles west of Molesworth's Peacock Tank.

		Feet	In.
3.	Conglomerate, limestone-chert, brownish weathering, but much finer than number 1. Reddish-drab, 7 feet to	8	
2.	Concealed, surface of part of interval strewn with plates of limestone conglomerate, much of it probably sandy shales	45	
1.	Conglomerate, coarse to fine, ferruginous to calcareous or even to limestone. Some rounded white quartz pebbles of fair size, some ferruginous, sandy, cherty, conglomerate, much sub-angular to rounded chert	50	

This section was taken on the south side of the road. On the north side of the road the thickness falls to 75 feet with more continuous exposures. Farther east on the north of the road is an exposure in a canyon showing red shales and some sandstone. At Shakespeare Tank there is a purplish, very dense, fine-grained limestone of considerable thickness in the conglomerate. The thickness of the conglomerate varies very considerably in short distances on account of the irregular surface upon which it is deposited. Its upper surface, however, grades into a somewhat sandy limestone and is quite even and regular.

The section as exposed north of the road is as follows:

		Feet	In.
3.	Conglomerate, fine, quite calcareous	15	
2.	Concealed. Carries some sandstone and conglomeratic limestone plates	25	

		Feet	In.
1.	Conglomerate, massive, very coarse, bottom bed completely cemented with iron at the surface, upper beds finer and more calcareous	35	

East of the edge of the Plateau, in Brackett Draw, rocks occur which are much higher in the section than any shown on the western side. These are light colored limestones, with peculiar fauna and appear to be the same as those seen west of the Jones Ranch house on the east side of Salt Flat, south of Seven Heart Gap. The fauna consists of a large *Spirifer* with quite large, angular plications, the first of the large, long *Fusulinae,* many brachiopods and bryozoa, etc. It is very distinct from anything seen farther west.

In the Diablo Mountains, just a little south of east of the south side of Black Mountain, rocks of still later age occur. In this place, the rock plunges eastward from the main escarpment and higher beds come in close to the edge of the flat. The hills or mountains on the edge of the flat near here are probably the youngest Paleozoic deposits connected with the Plateau. They are shales and dark limestones with sandy limestones and calcareous sandstones at the top. They carry an ammonoid fauna, which, while it has not been carefully studied, in all probability represents the fauna of the Word formation of the Glass Mountains. Some of the beds are very fossiliferous. One ordinary hand specimen yielded three genera of ammonoids, eight species of brachiopods, one species of pelecypod, one nautiloid, one *Orthoceras,* one pteropod or scaphopod, one sponge and one gastropod; more than 45 specimens in all. A large cylindrical species of *Fusulina* also occurs in the upper beds.

Section R

In the Northern Sierra Diablo, east of the south end of the Black Mountains.

		Feet	In.
36.	Limestone, quite sandy and even cross-bedded locally, rusty-buff shade, large robust *Fusulinas*	125-150±	
35.	Limestone, platy, yellowish, somewhat cherty, some yellow shales, etc.	8	
34.	Limestone, siliceous, rough, drab, beautifully preserved fossils, ammonoids, brachiopods, corals, etc.	7	

		Feet	In.
33.	Concealed	35	±
32.	Interval, 1 foot layer of limestone like number 28 at the top	50	
31.	Limestone mostly, like number 30, some concealed	45	
30.	Limestone, drab, much like number 28, but lighter colored within	10	
29.	Limestone, nodular, calcite crystals, drab, much of the rock less resistant than the rest and the beds concealed	45	
28.	Limestone, very fine-grained, drab, semi-conchoidal fracture, brown chert concretions below, limestone beds interspersed with less resistant beds not seen, 60 feet to	65	
27.	Interval. Part calcareous, hard, dark drab, slaty shales, many slabs of siliceous yellowish brown shale	25	
26.	Concealed, 2 feet of drab, finely granular limestone weathering gray at the top	20	
25.	Limestone, rather dark colored, giant *Spirifer*, *Fusulina*, gastropods, brachiopods	30	
24.	Limestone, rather thin-bedded, cherty, fossiliferous in upper part, long *Fusulina*, large *Productus*, *Spirifer*, etc. (Base of Section R^3)	35	
23.	Limestone, massive, brownish	20	
22.	Limestones, light, usually platy, some whitish spherules	5	
21.	Limestone, 3 beds, gray, prominent horizon markers, partings 3 to 6 feet thick	17	
20.	Concealed, shales or marls	5	
19.	Limestone, thin-bedded, light gray	35	
18.	Limestone, cavernous, buff-brown, geodes with dog-tooth spar, masses of green calcite	100	
17.	Limestone, massive, brownish, very finely crystalline to some extent, fossils, veins and masses of greenish to white calcite	80	
16.	Limestone, cherty (Base of Section R^2)	40	±
15.	Limestone reef, much like rocks below	77	
14.	Limestone, much like those below to base of the reef rock forming the north wall of canyon	60	
13.	Limestone, locally concealed, fossiliferous	30	
12.	Limestone, 1 bed, massive, very finely crystalline, varying in texture, light gray, fossils	80	
11.	Concealed. All limestone as shown in other parts of canyon	10	
10.	Limestone, soft, friable, nearly white, rounded crinoid fragments resembling large foraminifera	10	

		Feet	In.
9.	Limestone, massive, a little darker than 8	5	
8.	Limestone. poorly exposed, little "tooth" and some other fossils	20	
7.	Limestone, more craggy, lighter, and more coarsely crystalline than number 6	5	
6.	Limestone weathering gray, minute white specks, finely crystalline	5	
5.	Limestone, rather coarse, crystalline, drab-buff	5	
4.	Concealed, all limestone as shown in other parts of canyon	6	
3.	Limestone, very small *Fusulina*, some larger	6	
2.	Limestone much like number 1, coarser	15	
1.	Limestone, massive, buff-gray, very finely crystalline, some tiny geodes 20 feet above the base	60	

It is quite questionable if there is any relation between the first part of this section and the other two parts. R^1 (Nos. 1-17) is essentially a nearly white limestone without any chert, shales or marls, and in some exposures nearly without bedding planes. Fossils in it are rare, and usually quite small.

The beds of the section R^2 (Nos. 18-25), are much darker, somewhat cherty below and cavernous. There seems to be a fault separating the top of the first from the second section. That there has been some movement here is certain, but how much was not determined. A movement of some fifty feet was assumed and allowed for in making the section. Whether there is any duplication, or hiatus, in the section can not be stated on account of the limited time spent upon it.

Comanchean

The Comanchean rocks rest upon the Permian rocks on the south side of the Plateau, around the north side of the Black Mountains, and form a ring around the Cornudas Mountains. At one time they evidently covered the whole Plateau. The Comanchean is here represented as described by Richardson and since the rocks are aside from the discussion intended in this paper, it will be passed with two sections showing the stratigraphy of the beds.

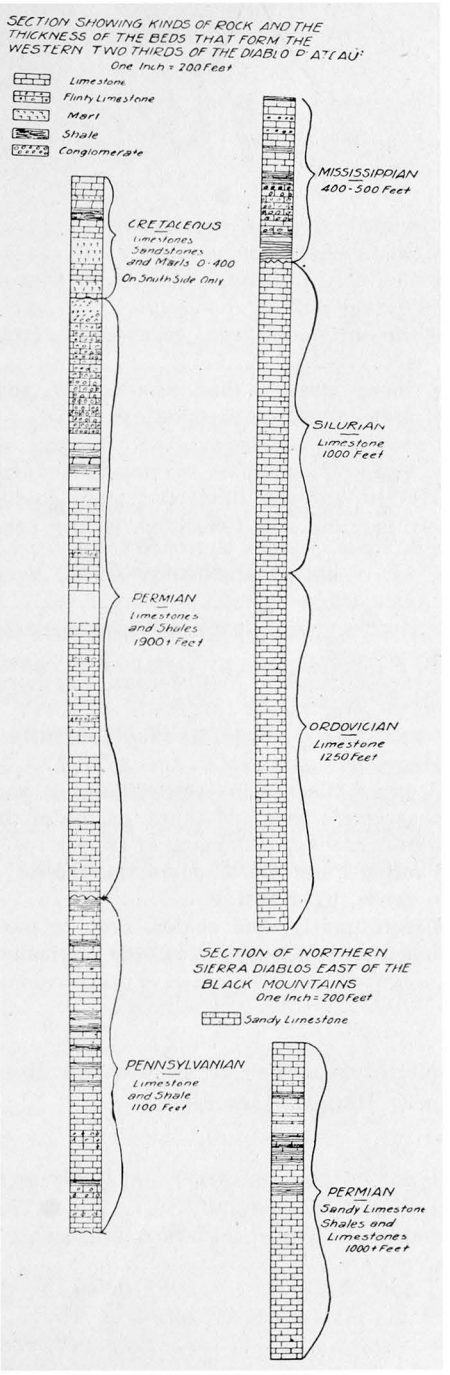

Figure 1. Sections showing kinds of rock and the thickness of the beds that form the western two-thirds of the Diablo Plateau. 1 inch—200 feet.

Section of Cretaceous rocks at Peacock Tank, Shakespeare "Mountains", northwest corner of Sand Mesa, a mile south of Shakespeare Tank.

		Feet	In.
18.	Limestone, comes in east of escarpment	30	+
17.	Limestone, massive, to top of cliff	40	
16.	Limestone, nodular, but more compact, to base of more massive limestone cliff	15	
15.	Marls, very fossiliferous, large gastropods, large *Protocardia*, etc	20	
14.	Limestone, more massive than number 13, somewhat nodular, platy sandstone in middle	35	
13.	Marls and nodular limestone	25	
12.	Limestone, buff-gray, massive, varying to nodular	15	
11.	Sandy-marly bed, and soft limestone, many fossils	25	
10.	Sandy-marly bed and soft limestone, locally sandstone, very fossiliferous, oysters, *Acteonella*, etc	10	
9.	Sandstone, sandy shales and sandy marls, very large oysters, *Acteonella*, etc	10	
8.	Limestone, rotten, and marls, *Trigonia*, *Acteonella*, large *Exogyra*, *etc*	28	
7	Limestone, rather massive, fossiliferous, weathers rusty, prominent	3	
6	Limestone and marls, finely nodular, fossiliferous in upper part	8	
5.	Limestone, gray, filled with *Acteonella*. A sandstone comes in as lenses here and there, on top of this bed. It sometimes reaches a thickness of twenty feet	6	
4.	Shales and rotten limestone, *Exogyra*, gastropods, etc	17	
3.	Limestone, dense, light buff	1	+
2.	Limestone, soft, marly, and shales, gray to dark buff, gypsiferous above. Used by Mexicans to plaster adobe houses	30	
1.	Concealed	90	

Section of northwest corner of Molesworth Mesa, Cretaceous rocks, southeast of Helms' East Well.

		Feet	In.
13.	Interval, lower 15 feet concealed, upper 5 feet mottled buff limestone, foraminiferal	20	
12.	Limestone, drab to buff, weathers rough, small pecten, foraminifera, etc	8	
11.	Sandstone, buff, weathers to brownish shade, thickens and thins and may pinch out locally	10	
10.	Limestone	11	

		Feet	In.
9.	Limestone, nodular, or rubbly, marly matrix, drab weathering light gray to dark gray, large oysters and gastropods	24	
8.	Concealed	6	
7.	Limestone, gray to dark buff, contains limestone pebbles, some of it semi-lithographic, conchoidal fracture, small *Ostrea, Exogyra texana?*, I foot to	2	
6	Concealed	15	
5	Conglomerate of fine-grained yellow sandstone with gray limestone, pebbles from size of marbles to hens' eggs or even larger	2	6
4.	Partly fine-grained gray sandstone, rest concealed	15	
3.	Sandstone, brownish, fine-grained, calcareous	2	6
2.	Concealed	1±	
1.	Limestone, buff, coarse, semi-crystalline	2±	

PLEISTOCENE-RECENT

All the more even surfaces of the whole Plateau are covered with surface wash, sometimes to considerable depth. At least the upper visible part of these deposits is of Pleistocene and Recent age. They are usually silts and gravels, or clays, ordinarily of buff to yellow tint. Over the larger part of the actual plateau surface they effectually conceal the rock surfaces so that the hills and ridges form isolated exposures, thus making the differentiation between the various horizons of the Manzano very difficult.

CORRELATION OF THE ANTHRACOLITIC ROCKS OF TEXAS WITH THOSE OF OKLAHOMA AND KANSAS

A tentative correlation chart is included here to show roughly the correlation of the Texas sections with those farther north. It will be noted that the Clear Fork beds are referred to the Hess formation of the Glass Mountains, largely on account of their relation to the great unconformity. This differs from Böse's correlation only in lowering the relative position of the Clear Fork stage and a slight elevation of the top of the Hess in central Texas. In other words, it is assumed that there was less erosion in the central Texas region prior to the deposition of the Leonard beds than there was in the Glass Mountains. Hence,

proportionally higher beds are preserved below this unconformity along the Colorado River than are left in the Marathon region. If this assumption is true it accounts for all the conditions present in both regions. It should be remarked that all the ammonoids from the higher beds of West Texas north of the Colorado River are from the Greer stage, and that the old Military Crossing locality, from which White's ammonoids came, lies in the Wichita stage, rather than in the Clear Fork.

The Pennsylvanian part of the chart is approximate and is intended to show the correlation only in a very general way.

The anthracolitic rocks of the Diablo Plateau have hitherto been referred to the Pennsylvanian system by most of those who have written upon them. From what has preceded it is apparent that the basal 400 to 600 feet of these rocks clearly belong to the Mississippian system. The fossils from these beds have been studied sufficiently by Professor Stuart Weller to warrant their reference to the Chester beds, here called Helms Group.

The next beds in the succession are correlated with the Magdalena group of New Mexico on one hand, and perhaps with the basal Gaptank of the Glass Mountains, Texas, on the other. They correspond to the Des Moines group of the Mississippi Valley, at least in part, especially the Henrietta stage. The higher beds may or may not reach above the Henrietta into the Kansas City stage.

Beds above the Magdalena group come in over a profound unconformity and are very much younger than the beds below. They are the formations of the Manzano stage—the Abo (in part?) Yeso, and San Andreas.

The fauna of the Manzano group as a whole, as described by Girty[1], is essentially a Wichita fauna as found on the Colorado River in Runnels County. It is not improbable that the basal Abo formation, if not all of it, in central New Mexico, is of upper Pennsylvanian age, and that there is a southward overlap

[1] U. S. Geol. Surv. Bull. 389, pp. 41-136. 1909.

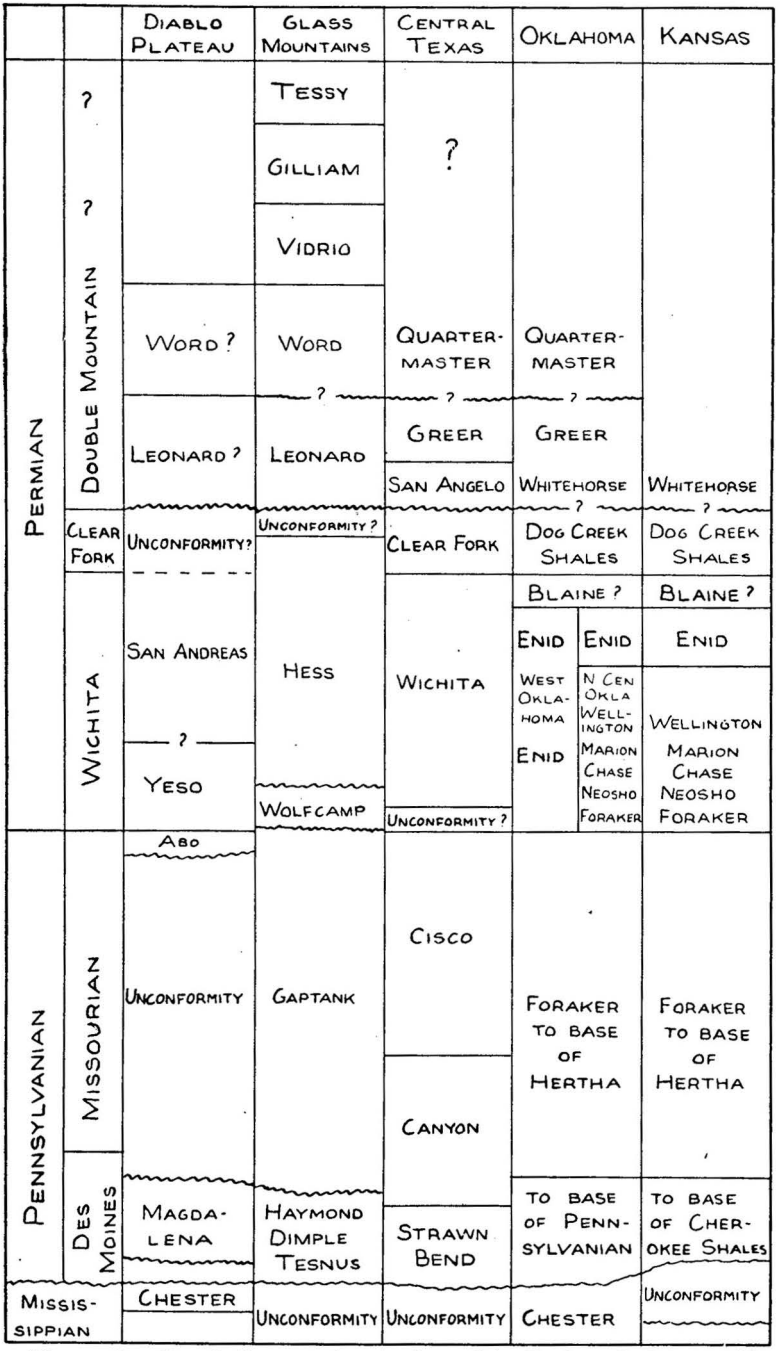

Figure 2. Correlation of the Anthracolitic Rocks of Texas with those of Oklahoma and Kansas.

of sediments on the unconformity. The upper part may or may not be of Pennsylvanian age[1].

If the Abo formation reaches into Texas along the Hueco Escarpment it is represented by limestones and shales at the base of Section B, and possibly at Sections I and J. However, this part of the section is at about the horizon of the unconformity between the Gaptank and Wolfcamp in the Glass Mountains.

The fauna of the Diablo Plateau is more of an off-shore fauna than either that of central New Mexico or of the Colorado River and north Texas region generally. The reason for this assumption is obvious from a physical point of view. In the central part of New Mexico the formations are sandstones, shales and limestones. Passing southward they change to an almost continuous limestone section in the Hueco Mountains in Texas. Along Red River practically the whole section is composed of shales and sandstones with a few thin limestones. On the Colorado River the limestones are much thicker, the shales thinner, and the sandstones wanting. Even the Silurian and Ordovician beds are limestones. These physical changes are accompanied by corresponding faunal changes, though some of the species appear to be common to nearly all the regions.

Upon cursory examination at least one species of *Omphalotrochus* appears to occur in the Huecos, in the Wichita stage of Runnels County, the basal Cibolo beds of the Shafter region, and the Wolfcamp beds of the Glass Mountains region. There are other similarities in the gastropod faunas of the regions.

Species of *Schwagerina* are found in the top of the Gaptank and in the Wolfcamp formations of the Glass Mountains, in the basal Manzano of the Huecos, and in beds of similar horizon in Kansas and Oklahoma. Species of the *S. fusulinoides* group also occur here, while they were originally described from the highest

[1]Since this was written, Böse and Baker have written articles apparently showing the Abo to be of Pennsylvanian age. See: Bose, E., "On Ammonoids of the Abo Sandstone of New Mexico and the age of the beds which contain them", Am. Journ. Sci., LXIX, pp. 51-60, 1920; Baker, C. L., "Contribution to the Stratigraphy of Eastern New Mexico", Am. Journ. Sci., LXIX, pp. 99-126, 1920.

of the "Fusulina beds" of the Carnic Alps, and are known from the Trogkofel beds.

The fusulinas of the three regions just mentioned are largely of the elongate type with highly crimped septa, similar to those of Kansas and the Glass Mountains near the Schwagerina horizon. In the light of these occurrences it should be remembered that the hiatus between the top of the Gaptank and the base of the Wolfcamp formations, of the Glass Mountains, is slight.

There is evidence accumulating that there is either a disconformity at the base of the Wichita Stage or that the base of the Wichita stage will have to be lowered somewhat in central Texas. A much more critical study of the transitional faunas is necessary before any final conclusion can be reached. That portion of the Manzano beds which comes in between the Huecos and the Salt Flat along the northern side of the Diablo Plateau is not favorably situated for study on the Texas side of the line and these beds will have to be worked out farther north.

As has already been stated, the highest beds bordering Salt Flat on the west are probably the equivalent of a part of the Delaware Mountain beds of west Texas, and of the Leonard and Word formations of the Marathon region.

Structure

Richardson's discussion of the major structure of the Diablo Plateau is clear and concise, and will not be repeated here. The major influence upon the structure of the region as a whole seems to have been from the southwest, giving a gentle northeast dip to the whole northern part of the Plateau. It brought up the older Paleozoic rocks at the south end of the Hueco Mountains and together with the influences that produced the structure of the Hueco Basin, west of the Hueco Mountains, formed the long structural ridges of the western part of the plateau with a northerly trend. In the immediate neighborhood of the larger intrusions of igneous rocks like Cerro Alto, the Cornudas and the Black Mountains, structures have been produced to some extent, apparently by sills and laccoliths, but in many cases these are of minor importance. The general direction of the dip of

the rocks is but little disturbed by these intrusions. However, it is the minor structures that are of interest to the petroleum geologist.

Minor Structures

These minor structures may be considered in two groups: Folds caused by igneous intrusions, and folds of the usual type.

The structures due to igneous intrusions are confined largely to the west and east ends of the plateau. Along the east edge of the Huecos from the New Mexico line southward for about half the length of the range, is a series of igneous masses of rocks appearing as intrusive bosses, dikes and sills. The largest mass of all is east of this line, on the edge of the Plateau, and is known as Cerro Alto.

Aside from those that appear at the surface there is evidence of others of somewhat similar nature. One of the most conspicuous of these is Neville Mountain, just east of Cerro Alto. Another illustration is the mountain west of Bird Dog Mountain at the east end of the Plateau. This mountain has the appearance of being elevated by an intrusion of igneous rocks beneath it. The mountain east of it was so formed and the rocks that covered it are weathered away revealing the granitic rocks of the core of the mountain. A smaller type of these structures is revealed in the region from the Black Mountains to the Cornudas. Here, small intrusions have formed structures of little area but excellent anticlines. In most cases the overlying rocks have been removed, but in some instances they still cover these masses of cooled lava. It would be useless to drill on these igneous structures. They are shown on the map.

The other structures are folds of various types, associated with faulting in the southwest part of the area, in the south end of the Hueco Mountains. Several of the valleys in the western part are structural, synclinal, anticlinal, or faulted. Some of the ridges are anticlinal to some extent, and some are monoclinal. Many of these structures are small, a mile or two in length, and others are much larger.

When the region as a whole is carefully detailed, there will be found to be no lack of structures to drill on. The main

question remaining is the likelihood of finding oil when the structures are drilled.

Drilling

The drilling will be through quite hard limestone, some of it well filled with chert, or flint, if the flint beds persist back under the plateau.

In the Ranger field the oil-producing rocks dip in a different direction from the surface rocks with the result that the coincidence of the surface and sub-surface structures is only partial, or general. On the Hueco Plateau there are from three to five sets of beds to be penetrated, depending upon the location of the well, each of which possesses a different dip from any of the others. As a result, the precise structures of the basal rocks are much less likely to coincide with surface structures than is the case in the Ranger field. This adds materially to the hazard of drilling and the expense of development.

Likelihood of Obtaining Oil in Commercial Quantities

This is, of course, the critical question, and upon this phase of the problem much of the time was spent. Even with the relatively large amount of work put in to determine this question it was impossible to do all that should have been done. However, a general survey of the situation was made, and careful sections of the rocks along the west and southwest sides of the plateau were made. A careful study of the rocks that make up this Plateau to a depth of five to six thousand feet does not reveal the presence of rocks which, as they appear at the surface, would seem to furnish a sufficient reservoir for the collection of the oil or gas.

However, the Ordovician and Silurian rocks at the base of the section carry considerable magnesia, and these may be changed to a crystalline dolomite locally, or may contain layers of it, which would render them sufficiently porous to serve as reservoirs. At best, this transformation would be local, here and there, and result in larger or smaller "pockets" of oil, though if dolomitic beds occur, they might form larger reservoirs. The likelihood of such local dolomitization is small, and the number

of holes necessary to test it out might be large. The minimum depth to which it would be necessary to drill to reach these rocks would be 3500 feet, unless the unconformities reduce the thickness of the section on the body of the Plateau. The shales at the base of the Mississippian rocks would form an ample cover for Silurian oil. The presence of a source of the oil, usually bituminous shales, is quite questionable in this case. No adequate source aside from the limestones themselves is known.

Taking everything into consideration, the chances of securing oil from these rocks, either Ordovician or Silurian, seem very slight indeed.

Locally there are thin sandstones in the top of the Helms group.

The next rocks to be taken into consideration are the Pennsylvanian limestones. Here there is an absence of large quantities of bituminous shales though much of the limestone is bituminous. There are sufficient shales or marls near the top of this formation to serve as a cap rock to retain any oil that might be present, but here the lack of porous rocks for reservoirs is even more noticeable than in the Silurian and Ordovician rocks. The limestones of which the formation is largely composed are nearly barren of magnesia.

There is a strong unconformity at the top of the Pennsylvanian beds, and it is possible that sandstones and shales may come in along this unconformity beneath the Plateau. However, there is little chance of finding sufficient sandy sediments there to be of much value as reservoirs.

Somewhat different conditions may obtain near the Salt Flat in the extreme northeast. In this region, higher formations are found and though but poorly exposed, some of them may contain sufficient sandstone to serve as reservoirs if a cap rock is available to retain the products. These higher formations reach about to the middle of the Permian. These formations are very near the surface and would be reached by shallow drilling.

Beneath these uppermost beds the section is supposed to be the same as on the western side of the Plateau, except that the various formations would be reached at much greater depths.

It is reported that oil or gas has been found some distance north of the Texas line in New Mexico. I have not verified this in the field and full data regarding it are not available to

me. If this is taken at its face value, it would seem that the greatest possibilities for oil on the Plateau would be on its north and northeast parts. Small showings of oil and gas will probably be found in drilling on the Diablo Plateau. At best, while it may be possible that a large oil field may be found on the Plateau yet, on account of the apparent scarcity of bituminous shales to furnish the oil, and more especially the apparent absence of porous strata to serve as reservoirs for oil or gas, the likelihood of it is remote.

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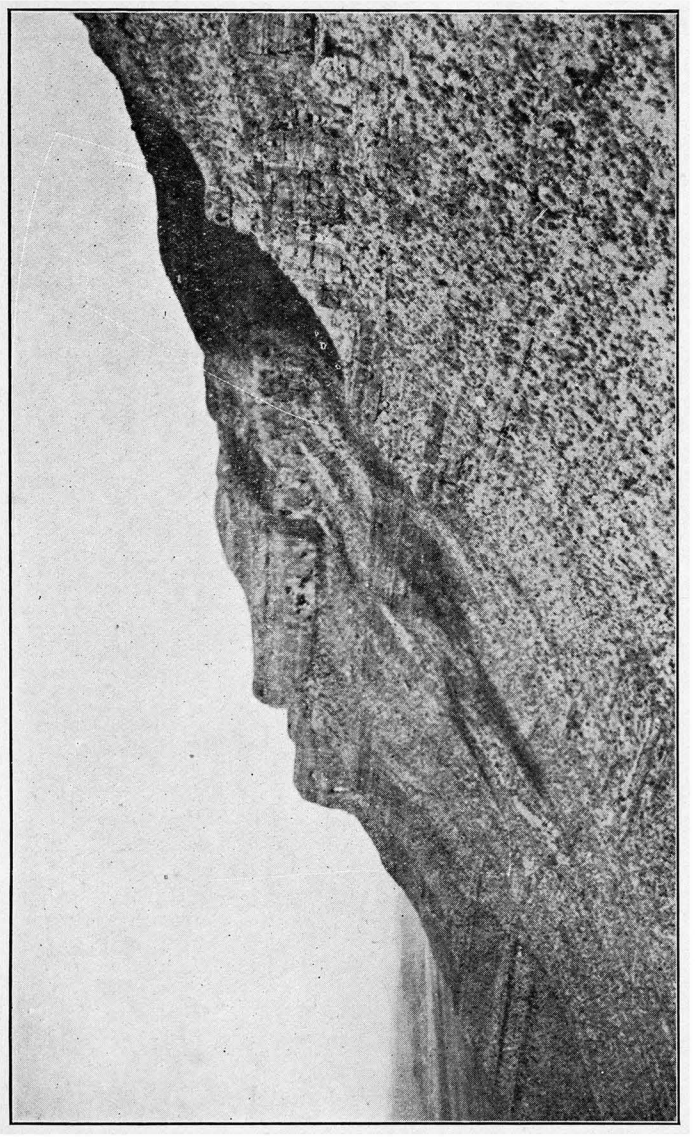
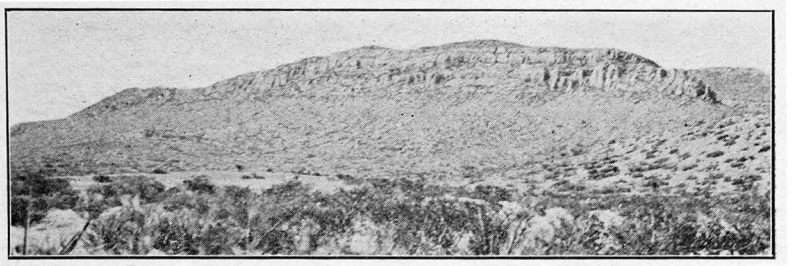
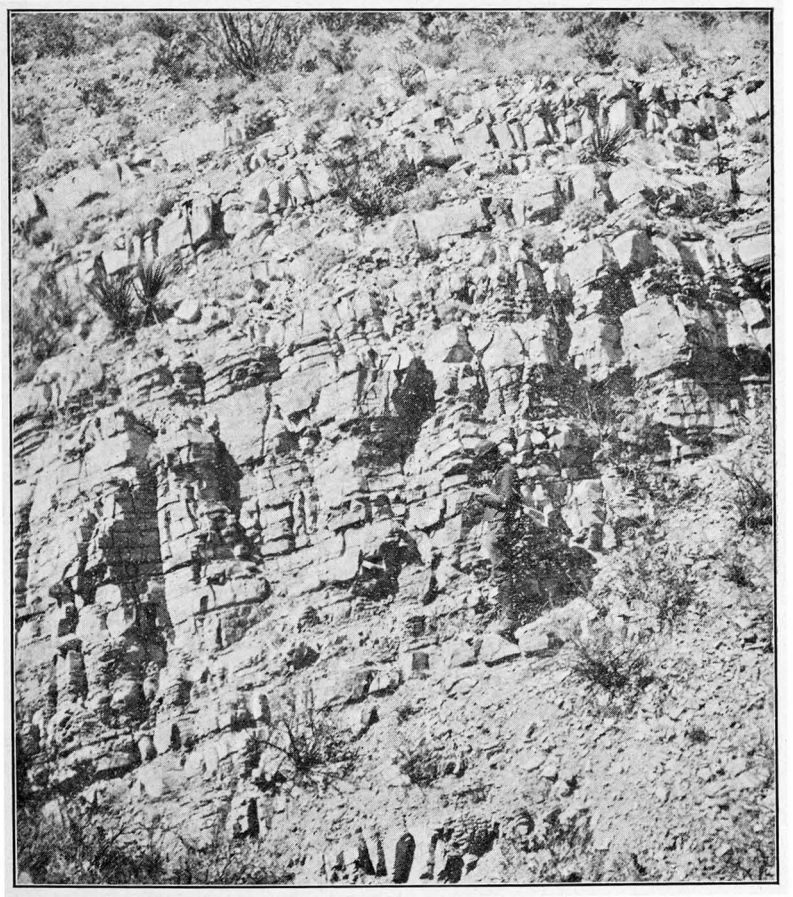


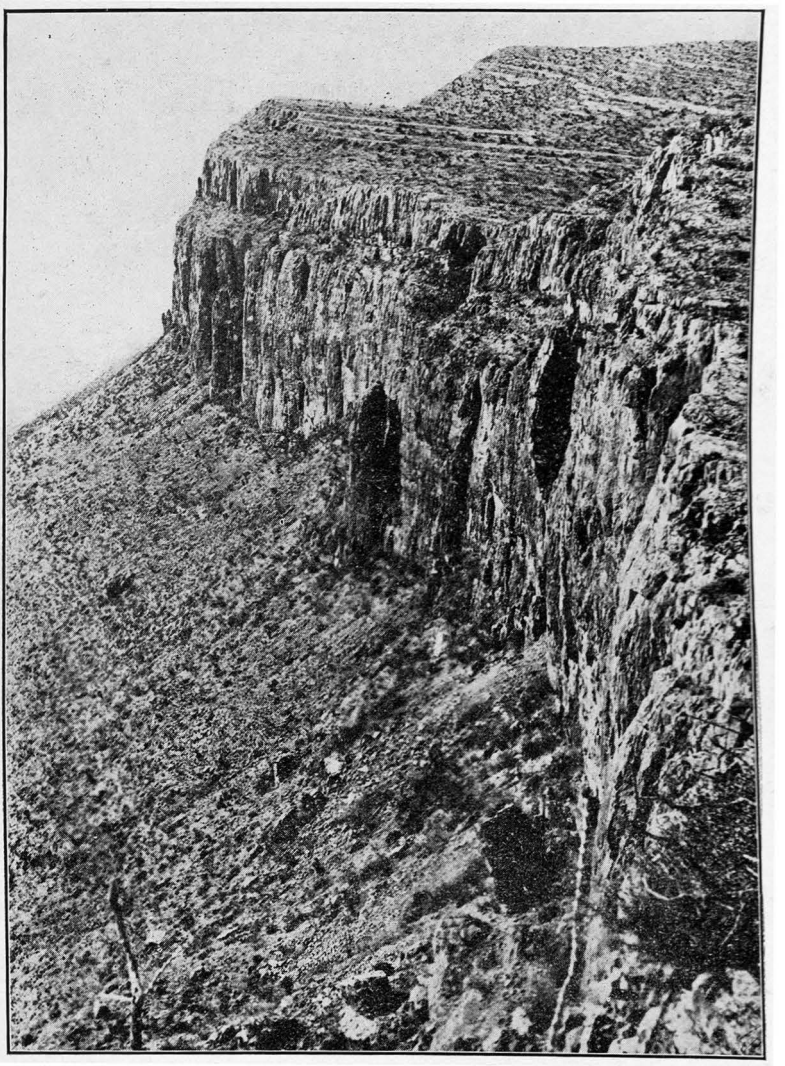
Hueco escarpment north of Hueco Canyon, looking north.



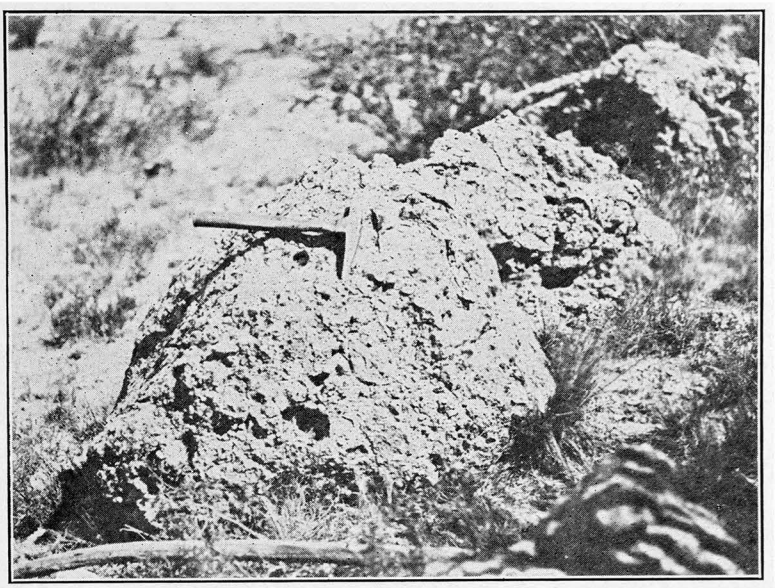
A. Looking north at Rancheria Mountain. Rocks from foreground to base of heavy limestone cliff are of Chester age.



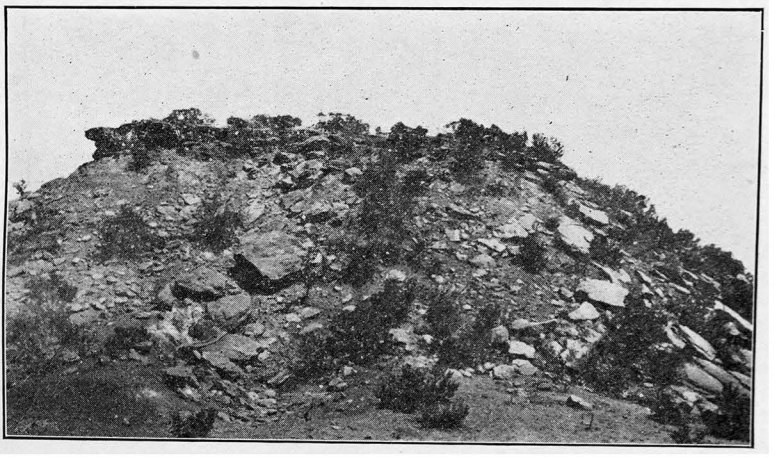
B. A detail of the Chester Outcrop as shown at Section C, about 8½ miles south of Hueco Tanks.



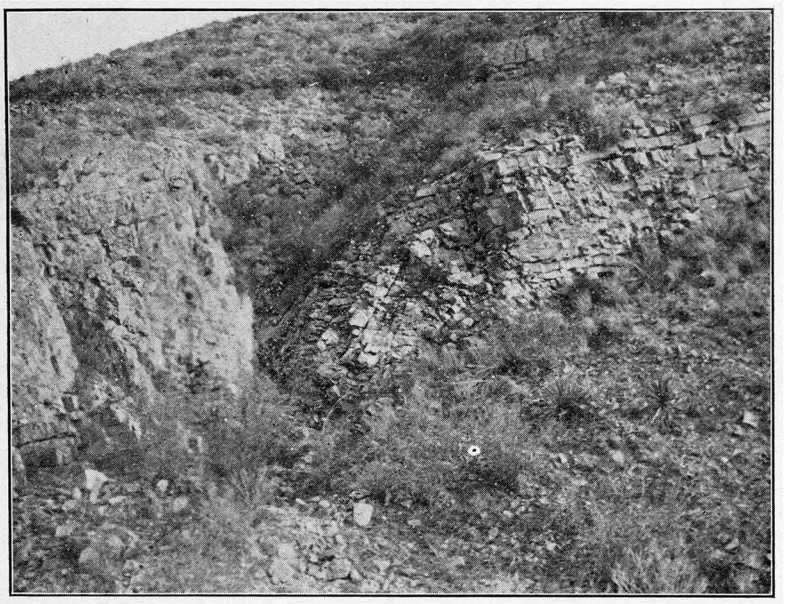
A detail of the Manzano Beds of the Hueco Escarpment, north of Hueco Canyon. Shows vertical weathering of the cliff with bedding but faintly developed.



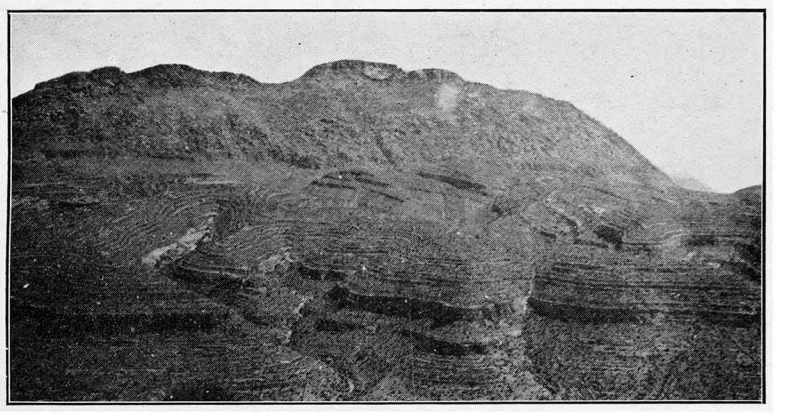
A. A detail of the conglomerate as seen south of the road west of Shakespeare Tank.



B. An exposure of the conglomerate north of the road at the same place.



A. A small fault showing drag. Seen from the road in upper part of Hueco Canyon.



B. Evenly inclined strata on the west foot of Cerro Alto dissected by small canyons producing beautifully curved outcrops. Seen from the mountain on west side of Lefthand canyon.

UNIVERSITY OF TEXAS
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J. A. UDDEN, DIRECTOR

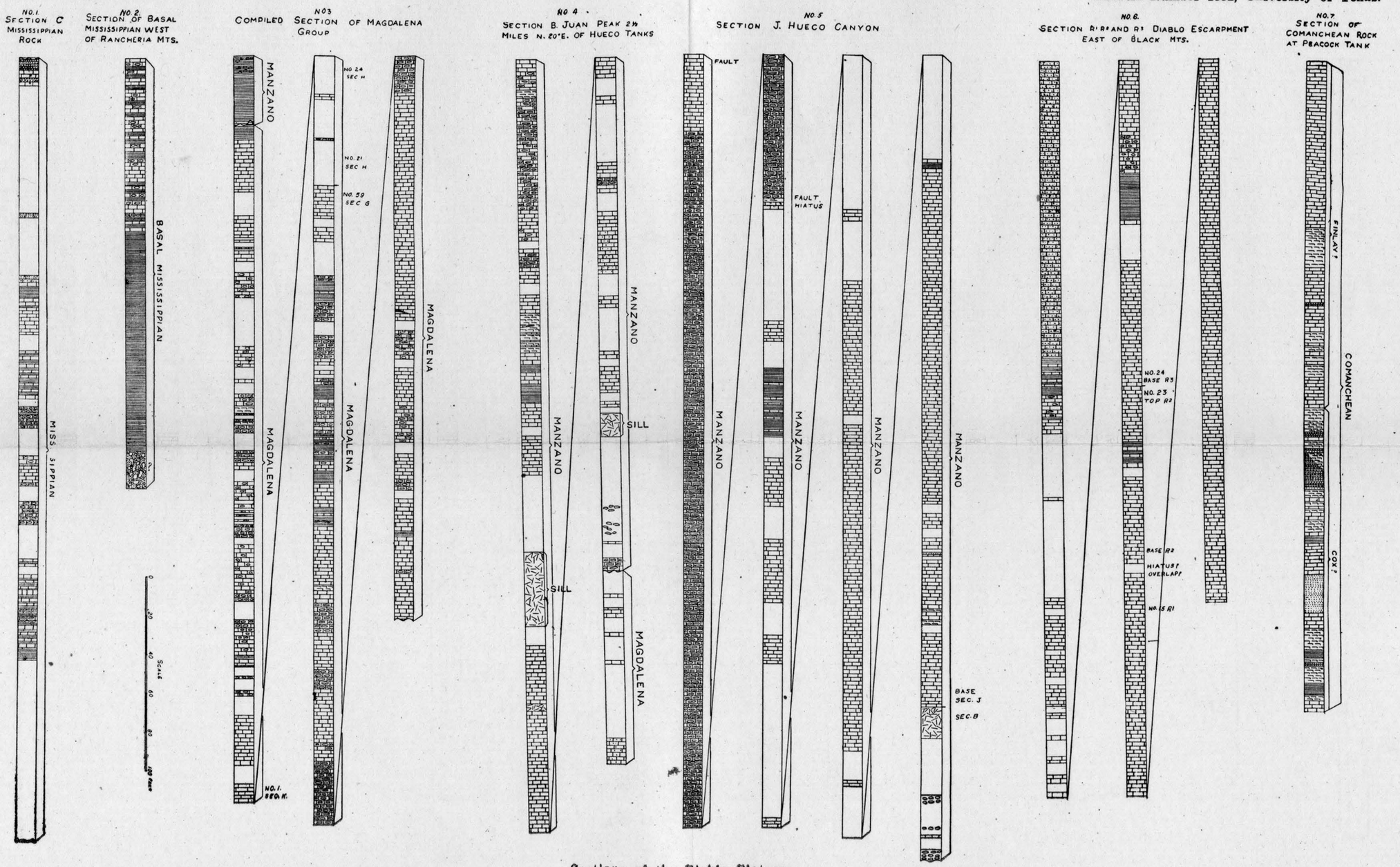
RECONNAISSANCE GEOLOGIC MAP OF NORTHERN DIABLO PLATEAU

BY
J. W. BEEDE AND C. E. BOWMAN

1919

Scale
1 0 1 2 3 4 5 Miles

Contour interval 250 feet.



Sections of the Diablo Plateau